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The detection and accuracy assessment of Pan-European yearly snow melt-off day derived from optical and microwave radiometer data

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Climate change has induced changes in the duration of seasonal snow cover in Global scale. Statistics of European snow cover duration, snow onset and melt-off dates have been derived earlier e.g. from MODIS snow products. We investigate the snow melt-off dates for years 2001-2016 using two different Earth observation-based snow products: i) Pan-European Fractional Snow Cover (FSC) provided through the Copernicus CryoLand service funded by the European Commission, and ii) Melt-off day product derived from passive microwave data produced by an algorithm developed at the Finnish Meteorological Institute. We are interested in the spring time snow depletion as according to e.g. [4], spring-time trends are more evident and have the greatest potential to affect the surface radiation budget, compared to the weaker trends in snow cover in fall.

We describe the methodology for deriving yearly pixel-wise snow melt-off day maps from optical data-based FSC (Fractional Snow Cover) without conducting any interpolation for cloud-obscured pixels or otherwise missing data. The Copernicus CryoLand Pan-European FSC time series for 2001-2016 re-gridded to 0.1° serves as input for the production of 16 years of melt-off day maps for Europe. These maps are compared with passive microwave radiometer (MWR) melt retrievals. These independent datasets are evaluated against melt-off day derived from in situ snow depth (SD) time series observed at European weather stations.
Our results show that the melt-off day derived from optical springtime FSC time series provides the best correlation with the snow melt-off day as indicated by in situ data. The obtained bias is 0.9 days, and RMSE is 13.1 days. For 85 % of the analyzed cases the differences are between $\pm$10 days. Across Europe the MWR-based detection of melt-off day is less accurate, as the applied method performs the best for areas with sustained seasonal snow cover. Based on the time series 1980-2016 for MWR-based melt-off day, separately for boreal forests and tundra, we also found a clear trend towards earlier snow clearance: a decrease of melt-off day by as much as $\sim$5 days per decade in boreal forests was observed, while tundra, the decrease of $\sim$3 day was found.